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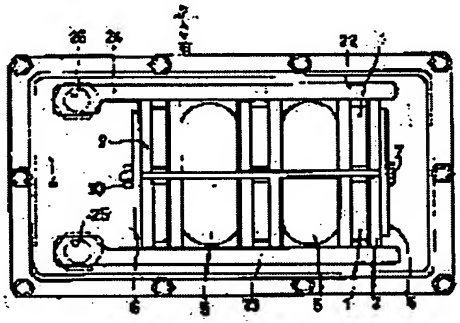
(71)Applicant : DENSO CORP
(72)Inventor : INOUE SEIJI

(54) DOUBLE-SIDED COOLING SEMICONDUCTOR DEVICE BY MEANS OF COOLANT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a double-sided cooling semiconductor device by means of coolant that has simple structure and excellent radiation capability.
SOLUTION: While a double-sided cooling semiconductor module 1 is provide closely to a coolant tube 2 that has a flat contact heat reception surface and allows cooling fluid to flow inside via an insulating spacer, the double-sided cooling semiconductor module 1 is clamped by clamping members 6, 7, and 10 in the thickness direction of the double-sided cooling semiconductor module 2 by the coolant tube 2, thus achieving the semiconductor device that has the simple structure, excellent cooling effect, and a small amount of fluctuation in the cooling effect.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The refrigerant cooling type double-side-cooling semiconductor device characterized by providing the following A semiconductor chip or a double-side-cooling type semiconductor module the compression which makes the aforementioned semiconductor chip or a double-side-cooling type semiconductor module compress in the thickness direction of a semiconductor chip or a double-side-cooling type semiconductor module by the aforementioned refrigerant tube by the state where the flat side of the aforementioned refrigerant tube was directly made close to both the principal planes of the refrigerant tube with which it has a flat contact heat-receiving side, and a cooling fluid flows the interior, and the aforementioned semiconductor chip or a double-side-cooling type semiconductor module through an insulating spacer -- a member
[Claim 2] It is the refrigerant cooling type double-side-cooling semiconductor device characterized by having two or more cooling fluid passage divided by the internal dividing wall which the aforementioned refrigerant tube separates a predetermined interval mutually in a refrigerant cooling type double-side-cooling semiconductor device according to claim 1, and is installed in the direction of passage.
[Claim 3] The ends of each aforementioned refrigerant tube which touches the aforementioned semiconductor chip or a double-sided thermolysis type semiconductor module in a refrigerant cooling type double-side-cooling semiconductor device according to claim 1 or 2, respectively are refrigerant cooling type double-side-cooling semiconductor devices characterized by connecting with a common entrance header and an outlet header, respectively.
[Claim 4] 3 is [a claim 1 or] the refrigerant cooling type double-side-cooling semiconductor device characterized by the aforementioned refrigerant tube touching the aforementioned semiconductor chip or a semiconductor module through the elasticity material of right thermal conductivity in the refrigerant cooling type double-side-cooling semiconductor device of a publication either.
[Claim 5] 4 is [a claim 1 or] the refrigerant cooling type double-side-cooling semiconductor device characterized by the aforementioned compression member containing a flat spring member in the refrigerant cooling type double-side-cooling semiconductor device of a publication either.
[Claim 6] It is the refrigerant cooling type double-side-cooling semiconductor device characterized by having the presser-foot board of a claim 1 or the couple to which the aforementioned compression member touches [in / the refrigerant cooling type double-side-cooling semiconductor device of a publication / 4 either] the aforementioned refrigerant tube of an outside couple individually most, the through bolt which penetrates both the aforementioned presser-feet board, and the nut screwed on the aforementioned through bolt.
[Claim 7] It is the refrigerant cooling type double-side-cooling semiconductor device characterized by for the aforementioned compression member having the presser-foot board of the couple which touches the aforementioned refrigerant tube of an outside couple individually most in a refrigerant cooling type double-side-cooling semiconductor device according to claim 5, forming the aforementioned flat spring member in the shape of a KO character, and both ends carrying out elastic energization of both the

aforementioned presser-feet board.
[Claim 8] a claim 1 or either of 7 -- the refrigerant cooling type double-side-cooling semiconductor device characterized by having the structure which arranges two or more sets of many aforementioned semiconductor chips or a double-side-cooling type semiconductor module, and many aforementioned refrigerant tubes in the aforementioned compression direction, and is compressed by the aforementioned compression member in the refrigerant cooling type double-side-cooling semiconductor device of a publication
[Claim 9] It is the refrigerant cooling type double-side-cooling semiconductor device characterized by two or more aforementioned semiconductor chips or a double-sided thermolysis type semiconductor module constituting a three phase inverter circuit in a refrigerant cooling type double-side-cooling semiconductor device according to claim 5.
[Claim 10] a claim 1 or either of 9 -- the refrigerant cooling type double-side-cooling semiconductor device characterized by having the structure which the flat side of other exoergic parts is made close to the flat side by the side of the anti-semiconductor chip of the aforementioned refrigerant tube, and compresses the aforementioned semiconductor chip or a double-side-cooling type semiconductor module, the aforementioned refrigerant tube, and the aforementioned exoergic parts by the aforementioned compression member in the refrigerant cooling type double-side-cooling semiconductor device of a publication
[Claim 11] For nothing and the aforementioned exoergic parts, the aforementioned semiconductor chip or a double-side-cooling type semiconductor module is a refrigerant cooling type double-side-cooling semiconductor device characterized by the bird clapper from the smoothing capacitor by which a part or all of a three phase inverter circuit is connected in a refrigerant cooling type double-side-cooling semiconductor device according to claim 10 between the positive/negative DC-power-supply edges of the aforementioned three phase inverter circuit.
[Claim 12] It is the refrigerant cooling type double-side-cooling semiconductor device which is held in a sealing case in a refrigerant cooling type double-side-cooling semiconductor device according to claim 3, and is characterized by having projected one edge each of the aforementioned entrance header and an outlet header to the aforementioned case shell exterior.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to a refrigerant cooling type double-side-cooling semiconductor device.
[0002]
[Description of the Prior Art] In order to improve the cooling nature of the semiconductor module which has a terminal and contains a semiconductor chip, contacting the cooling member of a water cooling type to a semiconductor module, and cooling it is proposed.
[0003] Moreover, the double-sided thermolysis type semiconductor module which performs thermolysis from both sides is proposed by JP,6-291223,A.
[0004]
[Problem(s) to be Solved by the Invention] It mentions above. however, by the conventional water cooling type semiconductor module Although it is the best for it to be necessary to aim at junction which was excellent in the thermal conductivity of the interior flowing-through cooling member of a refrigerant and semiconductor module with which water (or refrigerant) flows through in the interior, and to join to this the electrode (******) member and the interior flowing-through cooling member of a refrigerant which are exposed to the principal plane of a semiconductor module with solder etc. It is necessary to connect the interior flowing-through cooling member of a refrigerant to refrigerating cycle equipment or cooling-water-flow equipment. For this reason, it is necessary to interpose the insulating spacer which was excellent in thermal conductivity if possible with electric insulation between the interior flowing-through cooling member of a refrigerant used as these refrigerating cycle equipment, cooling-water-flow equipment, and this potential (usually grounding potential), and the above-mentioned polar-zone material of a semiconductor module.
[0005] However, since the polar-zone material of a semiconductor module and the interior flowing-through cooling member of a refrigerant are unjoinable if such an insulating spacer is used, it is necessary to force strongly the polar-zone material of these semiconductor module, and the interior flowing-through cooling member of a refrigerant to an insulating spacer by the uniform pressure by each part of a forcing side for reduction of the thermal resistance between the polar-zone material of a semiconductor module, and the interior flowing-through cooling member of a refrigerant.
[0006] However, the structure which forces a semiconductor module and the interior flowing-through cooling member of a refrigerant by the uniform pressure strong against an insulating spacer and in this way caused complication of whole structure, and a suitable setup of the forcing force was not easy for it. That is, if the forcing force is weak, the thermal resistance between a semiconductor module and a cooling member will increase, refrigeration capacity will decline, and if the forcing force is too strong, the semiconductor chip in a semiconductor module will break.
[0007] especially -- the front face of the polar-zone material of a semiconductor module, and cooling -- since minute irregularity, curvature, etc. which are not avoided on manufacture on the surface of a member exist, never, concentration of the local forcing force will not be able to be invited to a part of

direction of a field, and it will be able to push more than the forcing force in which a semiconductor chip can bear by this concentration part, consequently increase of thermal resistance other than this concentration part will be caused

[0008] this invention is made in view of the above-mentioned trouble, and it sets it as the purpose to offer the refrigerant cooling type double-side-cooling semiconductor device which can do so the thermolysis capacity excellent in simple structure.

[0009]

[Means for Solving the Problem] The refrigerant cooling type double-side-cooling semiconductor device according to claim 1 which attains the above-mentioned purpose A semiconductor chip or a double-side-cooling type semiconductor module, and the refrigerant tube with which it has a flat contact heat-receiving side, and a cooling fluid flows the interior, An insulating spacer is minded [of the aforementioned semiconductor chip or a double-side-cooling type semiconductor module / both] for the flat side of the aforementioned refrigerant tube. Or it is characterized by having the compression member which makes the aforementioned semiconductor chip or a double-side-cooling type semiconductor module compress in the thickness direction of a semiconductor chip or a double-side-cooling type semiconductor module by the aforementioned refrigerant tube by the state where it was directly made close.

[0010] That is, this composition has adopted the composition which sandwiches a double-sided thermolysis type semiconductor module (or semiconductor chip) by the refrigerant tube of a couple through an insulating spacer, and compresses these sets by the predetermined pressure by the compression member.

[0011] If it does in this way, two flat refrigerant tubes of semiconductor module (semiconductor chip) both sides can be pushed against a semiconductor module (semiconductor chip) by the same pressure by one compression member (when area of the polar-zone material of semiconductor module (semiconductor chip) both sides is made equal). The cooling performance which was excellent since the heat of a semiconductor module (semiconductor chip) was further radiated in the refrigerant tube of both sides while it could push with simple structure and dispersion in a pressure could realize small compression structure is realizable.

[0012] According to composition according to claim 2, in the refrigerant cooling type double-side-cooling semiconductor device according to claim 1, the aforementioned refrigerant tube is further characterized by having two or more cooling fluid passage divided by the internal dividing wall which separates a predetermined interval mutually and is installed in the direction of passage.

[0013] According to this composition, press of each part of a contact heat-receiving side of a refrigerant tube can be regularity-ized.

[0014] According to composition according to claim 3, it sets to a refrigerant cooling type double-side-cooling semiconductor device according to claim 1 or 2. further The ends of each aforementioned refrigerant tube which touches the aforementioned semiconductor chip or a double-sided thermolysis type semiconductor module, respectively According to . book composition connected to a common entrance header and an outlet header, respectively Reduce the temperature of the refrigerant which flows into each refrigerant tube, or a cooling fluid, and dispersion of a flow rate, can reduce temperature dispersion of each double-sided thermolysis type semiconductor module, and the cooling function of some each [these] semiconductor module falls. The fault that the maximum output of the whole circuit is restricted by that cause can be prevented.

[0015] Moreover, refrigerant transportation resistance of the refrigerant pipe line seen from the refrigerant pump or the compressor becomes small, and can reduce the power loss which it takes.

[0016] according to composition according to claim 4 -- a claim 1 or either of 3 -- in the refrigerant cooling type double-side-cooling semiconductor device of a publication, it is further characterized by the aforementioned refrigerant tube touching the aforementioned insulating spacer through the elasticity material of right thermal conductivity

[0017] Since a refrigerant tube is stuck to a semiconductor chip or a semiconductor module through elasticity material according to this composition, though curvature, surface irregularity, etc. are in a

refrigerant tube, a refrigerant tube can deform easily locally in each part according to the above-mentioned compression force, it can get used to the front face of an insulating spacer, and can reduce the thermal resistance between these both.
[0018] Furthermore, even if it changes the distance between the flat contact heat-receiving sides of the refrigerant tube which meets through the polar-zone material front face of a semiconductor module (semiconductor chip), it, and an elastic insulating spacer in each part of the direction of a field, these distance differences can be similarly reduced by local deformation of elasticity material, the thermal resistance between both can be reduced, and a semiconductor device with the outstanding cooling performance can be realized. In addition, this elasticity material may be separately produced with a refrigerant tube, and may be produced by one.
[0019] According to composition according to claim 5, in the claim 1 or the refrigerant cooling type double-side-cooling semiconductor device of any of 4, or a publication, the aforementioned compression member is further characterized by including a flat spring member.
[0020] according to this composition, while being able to acquire the fixed compression force easily, the desorption of a semiconductor chip or a double-sided thermolysis type semiconductor module becomes very easy, and workability, such as exchange, is markedly alike and improves
[0021] A flat spring member consists of a KO character-like metal plate with which both ends carry out elastic energization of both the aforementioned presser-feet board in a suitable mode. thus, flat spring if it carries out, when a spring plate etc. is bent, for example and it can produce simply -- a member -- since the compression force can be generated in itself, whole structure becomes simple
[0022] according to composition according to claim 6 -- a claim 1 or either of 5 -- in the refrigerant cooling type double-side-cooling semiconductor device of a publication, the aforementioned compression member is further characterized by having the presser-foot board of the couple which touches the aforementioned refrigerant tube of an outside couple individually most, the through bolt which penetrates both the aforementioned presser-feet board, and the nut screwed on the aforementioned through bolt
[0023] According to this composition, by energization of a through bolt, the presser-foot board which is the rigid body can pressurize each refrigerant tube with simple compression structure at the direction homogeneity of a field, and can reduce dispersion in the direction of a field of the compression force.
[0024] According to composition according to claim 7, in a refrigerant cooling type double-side-cooling semiconductor device according to claim 5, the aforementioned compression member has further the presser-foot board of the couple which touches the aforementioned refrigerant tube of an outside couple individually most, the aforementioned flat spring member is formed in the shape of a KO character, and both ends carry out elastic energization of both the aforementioned presser-feet board.
[0025] Since according to this composition a flat spring member also has a function as supporter material which supports a refrigerant tube and a double-sided thermolysis type semiconductor module while generating the compression force only in itself, whole structure becomes simple. Moreover, both ends bend the KO character-like metal plate which carries out elastic energization of both the aforementioned presser-feet board, then a spring plate, etc., and can produce a flat spring member simply.
[0026] according to composition according to claim 8 -- a claim 1 or either of 7 -- in the refrigerant cooling type double-side-cooling semiconductor device of a publication, it is further characterized by having the structure which arranges two or more sets of many aforementioned semiconductor chips or a double-side-cooling type semiconductor module, and many aforementioned refrigerant tubes in the aforementioned compression direction, and is compressed by the aforementioned compression member
[0027] According to this composition, since many compression force respectively equal to the refrigerant tube / semiconductor module (semiconductor chip) / refrigerant tube of a set can be given with the compression structure (compression member) of a piece, the high current controlled semiconductor device which was excellent in compact and simple compression structure as a whole is realizable.
[0028] According to composition according to claim 9, in a claim 1 or the refrigerant cooling type

double-side-cooling semiconductor device of any of 8, or a publication, two or more aforementioned semiconductor chips or a double-sided thermolysis type semiconductor module constitutes a three phase inverter circuit.
[0029] According to this composition, dispersion in thermolysis resistance of each solid-state-switching element of a three phase inverter circuit is reduced, temperature dispersion between them is reduced, one of each of the solid-state-switching element is overheated at an early stage, and equipment is not downed.
[0030] according to composition according to claim 10 -- a claim 1 or either of 9 -- in the refrigerant cooling type double-side-cooling semiconductor device of a publication, further, the flat side of other exoergic parts is made close to the flat side by the side of the anti-semiconductor chip of the aforementioned refrigerant tube, and it is characterized by having the structure which compresses the aforementioned semiconductor chip or a double-side-cooling type semiconductor module, the aforementioned refrigerant tube, and the aforementioned exoergic parts by the aforementioned compression member
[0031] According to this composition, the exoergic parts of further others can also be cooled good, without complicating compression structure.
[0032] Moreover, this exoergic part can achieve the function as a heat sink through a refrigerant tube to temporary large generation of heat of a semiconductor module (semiconductor chip), and it is still more convenient.
[0033] According to composition according to claim 11, in the refrigerant cooling type double-side-cooling semiconductor device according to claim 10, the aforementioned semiconductor chip or the double-side-cooling type semiconductor module is further characterized by the bird clapper by nothing and the aforementioned exoergic parts from the smoothing capacitor by which a part or all of a three phase inverter circuit is connected between the positive/negative DC-power-supply edges of the aforementioned three phase inverter circuit.
[0034] According to this composition, it is compact and the three phase inverter circuit apparatus excellent in the cooling nature of a smoothing capacitor and a semiconductor module (semiconductor chip) can be realized.
[0035] Since according to composition according to claim 12 equipment was held in the sealing case and one edge each of the aforementioned entrance header and an outlet header is projected outside from the aforementioned case in the refrigerant cooling type double-side-cooling semiconductor device according to claim 3, in the interior of a case, there is no mechanical connection section of the refrigerant pipe line, and accident of simplistic [of a semiconductor chip or a double-sided thermolysis type semiconductor module / the poor insulation or simplistic] can be made for there to be nothing by the liquid spill from this connection section.
[0036]
[Embodiments of the Invention] The suitable embodiment of the refrigerant cooling type double-side-cooling semiconductor device of this invention is explained below with reference to a drawing.
[0037]
[Example 1] Drawing 1 shows the important section decomposition thickness direction cross section of this refrigerant cooling type double-side-cooling semiconductor device.
(Composition of a semiconductor module) 1 is a spacer metal [2 / a double-side-cooling type semiconductor module and] in a refrigerant tube and 3, or right thermally conductive.
[0038] The semiconductor chip in which, as for 101a, the IGBT element was formed in the double-sided thermolysis type semiconductor module 1, The semiconductor chip in which, as for 101b, the fly wheel diode was formed, the metal heat exchanger plate to which 102 serves both as a heat sink and an electrode (this example emitter side), The metal heat exchanger plate to which 103 serves both as a heat sink and an electrode (this example collector side), The lobe in which a solder layer and 102a project to the semiconductor chip side of the metal heat exchanger plate 102 in 104, For the protrusion terminal area of the metal heat exchanger plate 103, and 105, as for a bonding wire and 8, a control-electrode terminal and 108 are [102b / the protrusion terminal area of the metal heat exchanger plate 102, and

103b / an electric insulating plate (insulating spacer said by this invention) and 9] the closure resin sections.
[0039] Semiconductor chips 101a and 101b are joined in the solder layer 104 on the principal plane inside the metal heat exchanger plate 103, lobe 102a of the metal heat exchanger plate 102 is joined to the principal plane of the remainder of semiconductor chips 101a and 101b in the solder layer 104, and, thereby, the anode electrode side and cathode electrode side of a fly wheel diode are connected to the so-called reverse parallel in the collector-electrode side and emitter electrode side of IGBT. Mo and W are used for the metal heat exchanger plates 102 and 103. You may replace the solder layer 104 by other junction functional materials.
[0040] Two lobes 102a has the difference of the thickness which absorbs the difference of the thickness of semiconductor chips 101a and 101b, and, thereby, the principal plane is a flat surface outside the metal heat exchanger plate 102.
[0041] The closure resin section 9 consists of an epoxy resin, it is wearing the side of these metal heat exchanger plates 102 and 103, the mould is carried out, and, thereby, the mould of the semiconductor chips 101a and 101b is carried out in the closure resin section 9. However, the principal plane, i.e., a contact heat-receiving side, is completely exposed outside the metal heat exchanger plates 102 and 103.
[0042] Projecting the protrusion terminal areas 102b and 103b from the closure resin section 9 to the method of the right among drawing 1 , two or more control-electrode terminals 105 which are the so-called leadframe terminals have connected the gate (control) electrode side and the control-electrode terminal 105 of semiconductor chip 101a with which IGBT was formed.
[0043] Although the electric insulating plate 8 which is an insulating spacer is constituted from this example by the alumimium nitride film, other insulating films are sufficient as it. Although the electric insulating plate 8 covered the metal heat exchanger plates 102 and 103 completely and has stuck them, as for an electric insulating plate 8 and the metal heat exchanger plates 102 and 103, contacting may also be good, right heat conductive guide members, such as silicone grease, may be applied, and they may be joined by various methods. Moreover, an insulating layer may be formed by ceramic flame spraying etc., and an electric insulating plate 8 may be joined on a metal heat exchanger plate, and you may join or form on a refrigerant tube.
[0044] The refrigerant tube 2 cuts the plate which drew out the aluminium alloy and was fabricated by the fabricating method or the extrusion-molding method to required length, and is produced. The thickness direction cross section of the refrigerant tube 2 has much passage 22 divided by the septum 21 of a large number which separate a predetermined interval mutually and extend in the direction of passage, as shown in drawing 1 .
[0045] Although the spacer (elasticity material as used in the field of this invention) 3 is used as elastic metal plates, such as a solder, in this example, it is good also as a film (film) formed in the contact surface of the metal heat exchanger plate 2 by application etc. The front face of this elastic spacer 3 deforms easily by compression mentioned later, gets used to the minute irregularity of an insulating material 8, curvature, and the minute irregularity and the curvature of the refrigerant tube 2, and reduces thermal resistance. In addition, well-known right thermal-conductivity grease etc. may be applied to the front face of a spacer 3 etc., and a spacer 3 may be omitted.
(Composition of a refrigerant cooling type double-side-cooling semiconductor device) The example of the refrigerant cooling type double-side-cooling semiconductor device using the double-sided thermolysis type semiconductor module mentioned above is explained below with reference to drawing 2 and drawing 3 . Drawing 2 shows the plan which removed the lid of this semiconductor device, and drawing 3 shows the drawing of longitudinal section.
[0046] For a presser-foot board and 9, as for a lid and 23, a flat spring member and 11 are [the smoothing capacitor of the couple to which a semiconductor module and 2 were carried out for 1, and parallel connection of the case of end opening and 5 was mutually carried out for a refrigerant tube and 4, and 6 / an entrance header and 24] an outlet header and a nut for [26 / 25 and] refrigerant piping fixation in refrigerant piping and 27.
[0047] The refrigerant piping 25 and 26 is being fixed to the pars basilaris ossis occipitalis of a case 4

with the nut, and the nose of cam of the refrigerant piping 25 and 26 penetrated the pars basilaris ossis occipitalis of a case 4, and has projected it caudad.
[0048] The refrigerant piping 25 and 26 is open for free passage within a case 4 at one to the soffit of the hollow plate-like entrance header 23 and the outlet header 24, headers 23 and 24 were set up by the base of a case 4 right-angled within the case 4, and separated the predetermined interval, and has met in parallel. Six pairs of refrigerant tubes 2 are arranged between the opposite principal planes of both the headers 23 and 24.
[0049] Each refrigerant tube 2 is arranged in parallel [with each other] right-angled with the principal plane of both the headers 23 and 24, respectively, and those ends are individually opened for free passage to both the headers 23 and 24, and it is joined. Each refrigerant tube 2 has a thick-plate configuration in the air so that it may mention later.
[0050] A pair of same refrigerant tubes 2 and 2 pinch the double-sided thermolysis type semiconductor module 1, and six modules 1 which constitute a three phase inverter circuit are pinched by a pair of mutually different refrigerant tubes 2 and 2.
[0051] the outside principal plane of the refrigerant tubes 2 and 2 which pinch a module 1, respectively -- respectively -- a metal -- monotonous -- a shell -- it presses down and a board 6 sticks -- having -- the set of these presser-feet board 6, the refrigerant tube 2, a module 1, the refrigerant tube 2, and the presser-foot board 6 -- flat spring -- it is compressed by the member 9 The presser-foot board 6 serves as a heat sink mass. flat spring -- a member 9 has the configuration which formed the spring-steel board in the shape of U character, and compresses it on both sides of the above-mentioned set among both ends in addition, the presser-foot board 6 -- omitting -- flat spring -- you may compress the refrigerant tube 2 of a couple, a module 1, and the refrigerant tube 2 directly by the member 6
[0052] The smoothing capacitor 5 had the flat configuration and has stuck the flat superficies to the back principal plane of a header 24.
[0053] Each semiconductor module 1 constitutes each solid-state-switching element of a three phase inverter circuit, and each solid-state-switching element carries out the antiparallel connection of the one fly wheel diode to one IGBT element, and is constituted. One side of the semiconductor modules 1 and 1 of each set makes the semiconductor module by the side of the high side of a single phase inverter circuit, and nothing and another side make the semiconductor module by the side of the high side of the single phase inverter circuit of the same phase. Therefore, three pairs of semiconductor modules 1 and 1 constitute the single phase inverter circuit of U, V, and W phase, respectively. A smoothing capacitor 5 is a smoothing capacitor connected between the positive/negative DC-power-supply edges of the above-mentioned three phase inverter circuit, and is for inhibiting that a switching noise is inputted into a DC-power-supply side through a power supply line.
[0054] Since the amount of uniform flows and an isothermal refrigerant are supplied through the entrance header 23, it is compressed by the still more common compression member and the compression area of the compression force per unit area between each semiconductor module 1 and the refrigerant tube 2 which spreads abbreviation etc. is also equal, the compression force of the refrigerant tube 2 over the semiconductor module 1 comes to spread abbreviation etc. on each refrigerant tube 2. Refrigeration capacity of each semiconductor module 1 can be made almost equal these results.
[0055]
[Example 2] The refrigerant cooling type double-side-cooling semiconductor device of other examples using the module 1 shown in drawing 1 is shown in drawing 4 and drawing 5 .
(Equipment configuration) Drawing 4 shows the plan which removed the lid of this semiconductor device, and drawing 5 shows the drawing of longitudinal section.
[0056] 1 -- a semiconductor module and 2 -- a refrigerant tube and 4 -- the case of end opening, and 5 -- for a through bolt and 10, as for a lid and 23, a nut and 11 are [a smoothing capacitor and 6 / a presser-foot board and 7 / an entrance header and 24] an outlet header and a nut for [26 / 25 and] refrigerant piping fixation in refrigerant piping and 27
[0057] Three pairs of flat refrigerant tubes 2 separate a predetermined interval in the thickness direction, and are ****(ed), and the semiconductor modules 1 and 1 of a couple are ****(ed) up and down among

drawing 2 among the refrigerant tubes 2 and 2 of each set. Each semiconductor module 1 constitutes each solid-state-switching element of a three phase inverter circuit, and each solid-state-switching element carries out the antiparallel connection of the one fly wheel diode to one IGBT element as mentioned above, and is constituted.

[0058] A smoothing capacitor 5 is a smoothing capacitor connected between the positive/negative DC-power-supply edges of the above-mentioned three phase inverter circuit, and is for inhibiting that a switching noise is inputted into a DC-power-supply side through a power supply line.

[0059] One side of a pair each of semiconductor modules 1 and 1 makes the semiconductor module by the side of the high side of a single phase inverter circuit, and nothing and another side make the semiconductor module by the side of the high side of the single phase inverter circuit of the same phase. Therefore, three pairs of semiconductor modules 1 and 1 constitute the single phase inverter circuit of U, V, and W phase, respectively.

[0060] The semiconductor modules 1 and 1 of each phase are sandwiched by the refrigerant tubes 2 and 2 as the both sides were explained to drawing 1 , and the flat cylindrical shape-like smoothing capacitor 5 is sandwiched among the refrigerant tubes 2 and 2 with which phases differ, respectively. Furthermore, it presses down in the refrigerant tubes 2 and 2 of a right-and-left maximum outside, a board 6 is contacted, a through bolt 7 is inserted in in the direction of a laminating at the upper-limit section and the soffit section of both the presser-feet boards 6 and 6, respectively, and it is concluded with the nut 10.

[0061] The conclusion force of a nut 10 is adjusted so that the compression force of the semiconductor module 1 by the refrigerant tubes 2 and 2 may serve as a predetermined value. That is, according to this example, the compression member which consists of the presser-foot board 6, a through bolt 7, and a nut 10 has the function to set up the compression force of the semiconductor module 1 by the refrigerant tubes 2 and 2, and the function as a structural member which assembles, carries out and supports a three phase inverter circuit apparatus.

[0062] As shown in drawing 3 , the right end of each refrigerant tube 2 is joined to the entrance header 23, the left end is joined to the outlet header 24, and the end of the entrance header 23 has projected the end of the outlet header 24 caudad from the pars basilaris ossis occipitalis of a case 4 through the refrigerant piping 26 of a refrigerant inlet side for the refrigerant piping 25 of a refrigerant inlet side. 27 is a nut which concludes and fixes the refrigerant piping 25 and 26 to the pars basilaris ossis occipitalis of a case 4.

[0063] Since the amount of uniform flows and an isothermal refrigerant are supplied through the entrance header 23, it is compressed by the still more common compression member and the compression area of the compression force per unit area between each semiconductor module 1 and the refrigerant tube 2 which spreads abbreviation etc. is also equal, the compression force of the refrigerant tube 2 over the semiconductor module 1 comes to spread abbreviation etc. on each refrigerant tube 2. Refrigeration capacity of each semiconductor module 1 can be made almost equal these results.

[0064] (Deformation mode) Even if it replaces the semiconductor module 1 of the above-mentioned example by the semiconductor chip, it can do the same operation effect so.

[0065]

[Example 3] The refrigerant cooling type double-side-cooling semiconductor device of other examples using the module 1 shown in drawing 1 is shown in drawing 6 and drawing 7 .

(Equipment configuration) Drawing 6 shows the plan which removed the lid of this semiconductor device, and drawing 7 shows the drawing of longitudinal section.

[0066] the flat spring which the equipment of this example considered the set of a module 1, the refrigerant tube 2, a smoothing capacitor 5, and the presser-foot board 6 as the same array as an example 2, and explained this set in the example 1 -- the large-sized flat spring which enlarged the member 9 -- it is made to pinch at once by the member 90 therefore, large-sized flat spring -- a member 90 consists of plate-like both ends 90a and 90a of the couple which is installed by it and the right angle, respectively and meets mutually from the both ends of central-plate section 90b of the piece arranged with a posture parallel to the pars basilaris ossis occipitalis of a case 4, and this central-plate section 90b 91 -- large-

sized flat spring -- it is the laesura section cut in central-plate section 90b of a member 90
[0067] According to this example, while being able to assemble each part material still more easily, the compression force in which dispersion is small can be given to each part material.

[Translation done.]

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(71)出願人　000004260
株式会社デンソー
愛知県刈谷市昭和町１丁目１番地
(72)発明者　井上　誠司
愛知県刈谷市昭和町１丁目１番地　株式会社デンソー内
(74)代理人　100081776
弁理士　大川　宏

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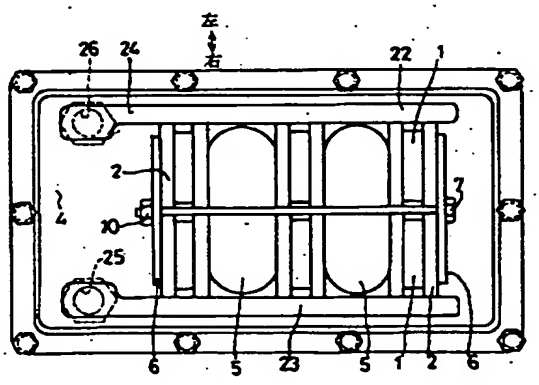
(54)【発明の名称】　冷媒冷却型両面冷却半導体装置

(57)【要約】
【課題】簡素な構造で優れた放熱能力を奏しえる冷媒冷却型両面冷却半導体装置を提供すること。
【解決手段】　両面冷却型半導体モジュール１と、扁平な接触受熱面を有して冷却流体が内部を流れる冷媒チューブ２とを絶縁スペーサを介して密接させた状態で両面冷却型半導体モジュール１を冷媒チューブ２にて両面冷却型半導体モジュール２の厚さ方向に挟圧部材６，７，１０で挟圧する。構造が簡素で冷却効果が大きく、冷却効果のばらつきが少ない半導体装置を実現できる。のさせるを備える。



【特許請求の範囲】
【請求項１】半導体チップ又は両面冷却型半導体モジュールと、
扁平な接触受熱面を有して冷却流体が内部を流れる冷媒チューブと、
前記半導体チップ又は両面冷却型半導体モジュールの両主面に前記冷媒チューブの平坦面を絶縁スペーサを介して又は直接に密接させた状態で前記半導体チップ又は両面冷却型半導体モジュールを前記冷媒チューブにて半導体チップ又は両面冷却型半導体モジュールの厚さ方向に挟圧させる挟圧部材と、
を備えることを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項２】請求項１記載の冷媒冷却型両面冷却半導体装置において、
前記冷媒チューブは、互いに所定間隔を隔てて流路方向へ延設される内部隔壁に区画される複数の冷却流体流路を有することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項３】請求項１又は２記載の冷媒冷却型両面冷却半導体装置において、
前記半導体チップ又は両面放熱型半導体モジュールにそれぞれ接する各前記冷媒チューブの両端は、共通の入り口ヘッダ及び出口ヘッダにそれぞれ接続されることを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項４】請求項１乃至３のいずれか記載の冷媒冷却型両面冷却半導体装置において、
前記冷媒チューブは良熱伝導性の軟質材を介して前記半導体チップ又は半導体モジュールに接することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項５】請求項１乃至４のいずれか記載の冷媒冷却型両面冷却半導体装置において、
前記挟圧部材は、板ばね部材を含むことを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項６】請求項１乃至４いずれか記載の冷媒冷却型両面冷却半導体装置において、
前記挟圧部材は、最も外側の一対の前記冷媒チューブに個別に接する一対の押さえ板と、前記両押さえ板を貫通するスルーボルトと、前記スルーボルトに螺着されるナットとを有することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項７】請求項５記載の冷媒冷却型両面冷却半導体装置において、
前記挟圧部材は、最も外側の一対の前記冷媒チューブに個別に接する一対の押さえ板を有し、
前記板ばね部材は、コ字状に形成されて両端部が前記両押さえ板を弾性付勢することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項８】請求項１乃至７のいずれか記載の冷媒冷却型両面冷却半導体装置において、
多数の前記半導体チップ又は両面冷却型半導体モジュールと多数の前記冷媒チューブとのセットを前記挟圧方向に複数配置して前記挟圧部材で挟圧する構造を有することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項９】請求項５記載の冷媒冷却型両面冷却半導体装置において、
複数の前記半導体チップ又は両面放熱型半導体モジュールは、三相インバータ回路を構成することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項１０】請求項１乃至９のいずれか記載の冷媒冷却型両面冷却半導体装置において、
前記冷媒チューブの反半導体チップ側の平坦面に他の発熱部品の平坦面を密接させ、前記挟圧部材で、前記半導体チップ又は両面冷却型半導体モジュールと前記冷媒チューブと前記発熱部品とを挟圧する構造を有することを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項１１】請求項１０記載の冷媒冷却型両面冷却半導体装置において、
前記半導体チップ又は、両面冷却型半導体モジュールは三相インバータ回路の一部又は全部をなし、
前記発熱部品は、前記三相インバータ回路の正負直流電源端間に接続される平滑コンデンサからなることを特徴とする冷媒冷却型両面冷却半導体装置。
【請求項１２】請求項３記載の冷媒冷却型両面冷却半導体装置において、
密閉ケースに収容され、前記入り口ヘッダ及び出口ヘッダの各一端は、前記ケースから外部に突出していることを特徴とする冷媒冷却型両面冷却半導体装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、冷媒冷却型両面冷却半導体装置に関する。
【０００２】
【従来の技術】端子を有し半導体チップを内蔵する半導体モジュールの冷却性を向上するために、半導体モジュールに水冷式の冷却部材を接触させてそれを冷却することが提案されている。
【０００３】また、両面から放熱を行う両面放熱型半導体モジュールが特開平６－２９１２２３号公報に提案されている。
【０００４】
【発明が解決しようとする課題】しかしながら、上述し従来の水冷式半導体モジュールでは、内部を水（又は冷媒）が貫流する冷媒内部貫流冷却部材と半導体モジュールとの熱伝導性に優れた接合を図る必要があり、これには、半導体モジュールの主面に露出する電極（兼伝熱）部材と冷媒内部貫流冷却部材とをはんだなどで接合することが最善であるが、冷媒内部貫流冷却部材は、冷凍サイクル装置や冷却水循環装置に接続する必要があり、このためこれら冷凍サイクル装置や冷却水循環装置と同電

位（通常、接地電位）となる冷媒内部貫流冷却部材と半導体モジュールの上記電極部材との間に電気絶縁性でなるべく熱伝導性に優れた絶縁スペーサを介設する必要がある。

【０００５】ところが、このような絶縁スペーサを用いると半導体モジュールの電極部材と冷媒内部貫流冷却部材とを接合することができないので、半導体モジュールの電極部材と冷媒内部貫流冷却部材との間の熱抵抗の低減のために、これら半導体モジュールの電極部材や冷媒内部貫流冷却部材を絶縁スペーサに強く、かつ、押し付け面各部で均一な圧力で押し付ける必要がある。

【０００６】しかし、このように半導体モジュールや冷媒内部貫流冷却部材を絶縁スペーサに強くかつ均一な圧力で押し付ける構造は全体構造の複雑化を招き、また押し付け力の適切な設定が容易ではなかった。すなわち、押し付け力が弱いと半導体モジュールと冷却部材との間の熱抵抗が増大して冷却能力が低下し、押し付け力が強過ぎると半導体モジュール内の半導体チップが割れてしまう。

【０００７】特に、半導体モジュールの電極部材の表面や冷却部材の表面には製造上避けられない微小凹凸や反りなどが存在するため、どうしても面方向の一部に局部的な押し付け力の集中を招いてしまい、この集中部位にて半導体チップが耐えうる押し付け力を超えて押し付けを行うことができず、その結果、この集中部位以外での熱抵抗の増大を招いてしまう。

【０００８】本発明は上記問題点に鑑みなされたものであり、簡素な構造で優れた放熱能力を奏しえる冷媒冷却型両面冷却半導体装置を提供することをその目的としている。

【０００９】

【課題を解決するための手段】上記目的を達成する請求項１記載の冷媒冷却型両面冷却半導体装置は、半導体チップ又は両面冷却型半導体モジュールと、扁平な接触受熱面を有して冷却流体が内部を流れる冷媒チューブと、前記半導体チップ又は両面冷却型半導体モジュールの両主面に前記冷媒チューブの平坦面を絶縁スペーサを介して又は直接に密接させた状態で前記半導体チップ又は両面冷却型半導体モジュールを前記冷媒チューブにて半導体チップ又は両面冷却型半導体モジュールの厚さ方向に挟圧させる挟圧部材とを備えることを特徴としている。

【００１０】すなわち、本構成は、両面放熱型半導体モジュール（又は半導体チップ）を絶縁スペーサを介して一対の冷媒チューブで挟み、挟圧部材でこれらのセットを所定圧力で挟圧する構成を採用している。

【００１１】このようにすれば、１個の挟圧部材で半導体モジュール（半導体チップ）両側の２つの扁平な冷媒チューブを同一圧力（半導体モジュール（半導体チップ）両側の電極部材の面積を等しいとした場合）で半導体モジュール（半導体チップ）に押し付けることができ、簡素な構造で押し付け圧力のばらつきが小さい挟圧構造を実現することができるとともに、更に半導体モジュール（半導体チップ）の熱を両側の冷媒チューブに放散することができるので優れた冷却性能を実現することができる。

【００１２】請求項２記載の構成によれば請求項１記載の冷媒冷却型両面冷却半導体装置において更に、前記冷媒チューブは、互いに所定間隔を隔てて流路方向へ延設される内部隔壁に区画される複数の冷却流体流路を有することを特徴としている。

【００１３】本構成によれば、冷媒チューブの接触受熱面各部の押圧を一定化することができる。

【００１４】請求項３記載の構成によれば請求項１又は２記載の冷媒冷却型両面冷却半導体装置において更に、前記半導体チップ又は両面放熱型半導体モジュールにそれぞれ接する各前記冷媒チューブの両端は、共通の入り口ヘッダ及び出口ヘッダにそれぞれ接続される．本構成によれば、各冷媒チューブに流入する冷媒又は冷却流体の温度、流量のばらつきを減らし、各両面放熱型半導体モジュールの温度ばらつきを低減でき、これら各半導体モジュールの一部の冷却機能が低下して、それにより回路全体の最大出力が制限されるという不具合を防止することができる。

【００１５】また、冷媒ポンプやコンプレッサからみた冷媒配管系の冷媒輸送抵抗が小さくなり、それに要する動力損失を低減することができる。

【００１６】請求項４記載の構成によれば請求項１乃至３のいずれか記載の冷媒冷却型両面冷却半導体装置において更に、前記冷媒チューブは良熱伝導性の軟質材を介して前記絶縁スペーサに接することを特徴としている。

【００１７】本構成によれば、冷媒チューブは、軟質材を介して半導体チップ又は半導体モジュールに密着するので、もし冷媒チューブに反りや表面凹凸などがあったとしても、冷媒チューブは上記挟圧力によりその各部において局所的に容易に変形して絶縁スペーサの表面になじむことができ、これら両者間の熱抵抗を低減することができる。

【００１８】更に、半導体モジュール（半導体チップ）の電極部材表面とそれと軟質の絶縁スペーサを介して対面する冷媒チューブの平坦な接触受熱面との間の距離が面方向各部において変動しても、同様に軟質材の局所的変形によりこれらの距離差を低減して両者間の熱抵抗を低減することができ、優れた冷却性能をもつ半導体装置を実現することができる。なお、この軟質材は、冷媒チューブと別々に作製されてもよく、一体に作製されてもよい。

【００１９】請求項５記載の構成によれば請求項１乃至４のいずれか記載の冷媒冷却型両面冷却半導体装置において更に、前記挟圧部材は、板ばね部材を含むことを特徴としている。

【００２０】本構成によれば、簡単に一定の挟圧力を得ることができるとともに、半導体チップ又は両面放熱型半導体モジュールの脱着が極めて簡単となり、交換などの作業性が格段に向上する。

【００２１】好適な態様において、板ばね部材は、両端部が前記両押さえ板を弾性付勢するコ字状金属板からなる。このようにすれば、たとえばばね板などを折り曲げるなどして簡素に作製できる上、板ばね部材それ自体で挟圧力を発生できるため、全体構造が簡素となる。

【００２２】請求項６記載の構成によれば請求項１乃至５のいずれか記載の冷媒冷却型両面冷却半導体装置において更に、前記挟圧部材は、最も外側の一対の前記冷媒チューブに個別に接する一対の押さえ板と、前記両押さえ板を貫通するスルーボルトと、前記スルーボルトに螺着されるナットとを有することを特徴としている。

【００２３】本構成によれば、剛体である押さえ板が、スルーボルトの付勢により、簡素な挟圧構造で各冷媒チューブを面方向均一に加圧することができ、挟圧力の面方向のばらつきを低減することができる。

【００２４】請求項７記載の構成によれば請求項５記載の冷媒冷却型両面冷却半導体装置において更に、前記挟圧部材は、最も外側の一対の前記冷媒チューブに個別に接する一対の押さえ板を有し、前記板ばね部材は、コ字状に形成されて両端部が前記両押さえ板を弾性付勢する。

【００２５】本構成によれば、板ばね部材はそれ自身のみで挟圧力を発生するとともに、冷媒チューブや両面放熱型半導体モジュールを支持する支持部材としての機能ももつので、全体構造が簡素となる。また、板ばね部材は、両端部が前記両押さえ板を弾性付勢するコ字状金属板とすれば、ばね板などを折り曲げるなどして簡素に作製できる。

【００２６】請求項８記載の構成によれば請求項１乃至７のいずれか記載の冷媒冷却型両面冷却半導体装置において更に、多数の前記半導体チップ又は両面冷却型半導体モジュールと多数の前記冷媒チューブとのセットを前記挟圧方向に複数配置して前記挟圧部材で挟圧する構造を有することを特徴としている。

【００２７】本構成によれば、一個の挟圧構造（挟圧部材）で多数セットの冷媒チューブ／半導体モジュール（半導体チップ）／冷媒チューブにそれぞれ等しい挟圧力を付与することができるので、コンパクトで簡素な挟圧構造で全体として優れた大電流制御半導体装置を実現することができる。

【００２８】請求項９記載の構成によれば請求項１乃至８のいずれか記載の冷媒冷却型両面冷却半導体装置において、複数の前記半導体チップ又は両面放熱型半導体モジュールは、三相インバータ回路を構成する。

【００２９】本構成によれば、三相インバータ回路の各半導体スイッチング素子の放熱抵抗のばらつきを低減してそれらの間の温度ばらつきを低減し、各半導体スイッチング素子の一つが早期に過熱して装置がダウンすることがない。

【００３０】請求項１０記載の構成によれば請求項１乃至９のいずれか記載の冷媒冷却型両面冷却半導体装置において更に、前記冷媒チューブの反半導体チップ側の平坦面に他の発熱部品の平坦面を密接させ、前記挟圧部材で、前記半導体チップ又は両面冷却型半導体モジュールと前記冷媒チューブと前記発熱部品とを挟圧する構造を有することを特徴としている。

【００３１】本構成によれば、挟圧構造を複雑化することなく、更に他の発熱部品も良好に冷却することができる。

【００３２】また、半導体モジュール（半導体チップ）の一時的な大発熱に対してこの発熱部品は冷媒チューブを通じてヒートシンクとしての機能を果たすことができ、更に好都合である。

【００３３】請求項１１記載の構成によれば請求項１０記載の冷媒冷却型両面冷却半導体装置において更に、前記半導体チップ又は両面冷却型半導体モジュールは三相インバータ回路の一部又は全部をなし、前記発熱部品は、前記三相インバータ回路の正負直流電源端間に接続される平滑コンデンサからなることを特徴としている。

【００３４】本構成によれば、コンパクトで平滑コンデンサ及び半導体モジュール（半導体チップ）の冷却性に優れた三相インバータ回路装置を実現することができる。

【００３５】請求項１２記載の構成によれば請求項３記載の冷媒冷却型両面冷却半導体装置において、装置は密閉ケースに収容され、前記入り口ヘッダ及び出口ヘッダの各一端は、前記ケースから外部に突出しているので、ケース内部において、冷媒配管系の機械的連結部がなく、この連結部からの液漏れにより半導体チップや両面放熱型半導体モジュールの絶縁不良や短絡といった事故を皆無とすることができる。

【００３６】

【発明の実施の形態】本発明の冷媒冷却型両面冷却半導体装置の好適な実施態様を図面を参照して以下説明する。

【００３７】

【実施例１】図１はこの冷媒冷却型両面冷却半導体装置の要部分解厚さ方向断面図を示す。

（半導体モジュールの構成）１は、両面冷却型半導体モジュール、２は冷媒チューブ、３は金属製又は良熱伝導性のスペーサである。

【００３８】両面放熱型半導体モジュール１において、１０１ａはＩＧＢＴ素子が形成された半導体チップ、１０１ｂはフライホイルダイオードが形成された半導体チップ、１０２はヒートシンク及び電極（この実施例ではエミッタ側）を兼ねる金属伝熱板、１０３はヒートシン

ク及び電極（この実施例ではコレクタ側）を兼ねる金属伝熱板、１０４ははんだ層、１０２ａは金属伝熱板１０２の半導体チップ側へ突出する突出部、１０２ｂは金属伝熱板１０２の突出端子部、１０３ｂは金属伝熱板１０３の突出端子部、１０５は制御電極端子、１０８はボンディングワイヤ、８は絶縁板（本発明で言う絶縁スペーサ）、９は封止樹脂部である。

【００３９】半導体チップ１０１ａ、１０１ｂは、金属伝熱板１０３の内側の主面上にはんだ層１０４で接合され、半導体チップ１０１ａ、１０１ｂの残余の主面には、金属伝熱板１０２の突出部１０２ａがはんだ層１０４で接合され、これによりＩＧＢＴのコレクタ電極面及びエミッタ電極面にフライホイルダイオードのアノード電極面及びカソード電極面がいわゆる逆並列に接続されている。金属伝熱板１０２、１０３にはたとえばＭｏやＷが用いられている。はんだ層１０４を他の接合機能材料に置換してもよい。

【００４０】二つの突出部１０２ａは、半導体チップ１０１ａ、１０１ｂの厚さの差を吸収する厚さの差をもち、これにより金属伝熱板１０２の外主面は平面となっている。

【００４１】封止樹脂部９はたとえばエポキシ樹脂からなり、これら金属伝熱板１０２、１０３の側面を覆ってモールドされており、これにより半導体チップ１０１ａ、１０１ｂは封止樹脂部９でモールドされている。ただし、金属伝熱板１０２、１０３の外主面すなわち接触受熱面は完全に露出している。

【００４２】突出端子部１０２ｂ、１０３ｂは封止樹脂部９から図１中、右方に突出し、いわゆるリードフレーム端子である複数の制御電極端子１０５は、ＩＧＢＴが形成された半導体チップ１０１ａのゲート（制御）電極面と制御電極端子１０５とを接続している。

【００４３】絶縁スペーサである絶縁板８は、この実施例では窒化アルミニウムフィルムで構成されているが、他の絶縁フィルムでもよい。絶縁板８は金属伝熱板１０２、１０３を完全に覆って密着しているが、絶縁板８と金属伝熱板１０２、１０３とは、単に接触するだけでもよいし、シリコングリスなどの良熱伝導材を塗布してもよいし、それらを種々の方法で接合させてもよい。また、セラミック溶射などで絶縁層を形成してもよく、絶縁板８を金属伝熱板上に接合してもよく、冷媒チューブ上に接合又は形成してもよい。

【００４４】冷媒チューブ２は、アルミニウム合金を引き抜き成形法あるいは押し出し成形法で成形された板材を必要な長さに切断して作製されている。冷媒チューブ２の厚さ方向断面は、図１に示すように、互いに所定間隔を隔てて流路方向に延在する多数の隔壁２１で区画された流路２２を多数有している。

【００４５】スペーサ（本発明でいう軟質材）３は、この実施例では、はんだ合金などの軟質の金属板とされているが、金属伝熱板２の接触面に塗布などにより形成したフィルム（膜）としてもよい。この軟質のスペーサ３の表面は、後述する挟圧により容易に変形して、絶縁材８の微小凹凸や反り、冷媒チューブ２の微小凹凸や反りになじんで熱抵抗を低減する。なお、スペーサ３の表面などに公知の良熱伝導性グリスなどを塗布してもよく、スペーサ３を省略してもよい。

（冷媒冷却型両面冷却半導体装置の構成）上述した両面放熱型半導体モジュールを用いた冷媒冷却型両面冷却半導体装置の例を図２、図３を参照して以下に説明する。図２は、この半導体装置の蓋を外した平面図を示し、図３はその縦断面図を示す。

【００４６】１は半導体モジュール、２は冷媒チューブ、４は一端開口のケース、５は互いに並列接続された一対の平滑コンデンサ、６は押さえ板、９は板ばね部材、１１は蓋、２３は入り口ヘッダ、２４は出口ヘッダ、２５、２６は冷媒配管、２７は冷媒配管固定用のナットである。

【００４７】ケース４の底部には、ナットにより冷媒配管２５、２６が固定されており、冷媒配管２５、２６の先端はケース４の底部を貫通して下方に突出している。

【００４８】冷媒配管２５、２６はケース４内にて、中空平板状の入り口ヘッダ２３、出口ヘッダ２４の下端に一体に連通しており、ヘッダ２３、２４はケース４内にてケース４の底面に直角に立設され、所定間隔を隔てて平行に対面している。両ヘッダ２３、２４の対向主面間に６対の冷媒チューブ２は配置されている。

【００４９】各冷媒チューブ２は、それぞれ両ヘッダ２３、２４の主面と直角かつ互いに平行に配置され、それらの両端は両ヘッダ２３、２４に個別に連通、接合されている。各冷媒チューブ２は後述するように中空の厚板形状を有する。

【００５０】同一対の冷媒チューブ２、２は両面放熱型半導体モジュール１を挟持し、三相インバータ回路を構成する６個のモジュール１は互いに異なる対の冷媒チューブ２、２で挟持されている。

【００５１】それぞれモジュール１を挟持する冷媒チューブ２、２の外側主面にはそれぞれ金属平板からなる押さえ板６が密着され、これら押さえ板６、冷媒チューブ２、モジュール１、冷媒チューブ２、押さえ板６のセットは板ばね部材９により挟圧されている。押さえ板６はヒートシンクマスを兼ねる。板ばね部材９は、バネ鋼板をＵ字状に形成した形状を有し、両端部間に上記セットを挟んで挟圧する。なお、押さえ板６を省略して板ばね部材６で一対の冷媒チューブ２、モジュール１、冷媒チューブ２を直接挟圧してもよい。

【００５２】平滑コンデンサ５は、扁平形状を有し、その平坦外面はヘッダ２４の裏主面に密着している。

【００５３】各半導体モジュール１は三相インバータ回路の各半導体スイッチング素子を構成しており、各半導

体スイッチング素子は１個のＩＧＢＴ素子に１個のフライホイルダイオードを逆並列接続して構成されている。各対の半導体モジュール１、１の一方は単相インバータ回路のハイサイド側の半導体モジュールをなし、他方は同一相の単相インバータ回路のハイサイド側の半導体モジュールをなす。したがって、３対の半導体モジュール１、１はそれぞれＵ、Ｖ、Ｗ相の単相インバータ回路を構成している。平滑コンデンサ５は、上記三相インバータ回路の正負直流電源端間に接続される平滑コンデンサであり、電源ラインを通じて直流電源側にスイッチングノイズが入力されるのを抑止するためのものである。

【００５４】各冷媒チューブ２には、入り口ヘッダ２３を通じて等流量かつ等温の冷媒が供給され、更に、共通の挟圧部材で挟圧されるため各半導体モジュール１と冷媒チューブ２との間の単位面積当たりの挟圧力は略等しく、挟圧面積も等しいので、半導体モジュール１に対する冷媒チューブ２の挟圧力が略等しくなる。これらの結果、各半導体モジュール１の冷却能力はほぼ等しくすることができる。

【００５５】

【実施例２】図１に示すモジュール１を用いた他の実施例の冷媒冷却型両面冷却半導体装置を図４、図５に示す。

（装置構成）図４は、この半導体装置の蓋を外した平面図を示し、図５はその縦断面図を示す。

【００５６】１は半導体モジュール、２は冷媒チューブ、４は一端開口のケース、５は平滑コンデンサ、６は押さえ板、７はスルーボルト、１０はナット、１１は蓋、２３は入り口ヘッダ、２４は出口ヘッダ、２５、２６は冷媒配管、２７は冷媒配管固定用のナットである。

【００５７】３対の扁平な冷媒チューブ２が、その厚さ方向に所定間隔を隔てて隔設され、各対の冷媒チューブ２、２の間に図２中、上下に一対の半導体モジュール１、１が挟設されている。各半導体モジュール１は三相インバータ回路の各半導体スイッチング素子を構成しており、各半導体スイッチング素子は上述のように１個のＩＧＢＴ素子に１個のフライホイルダイオードを逆並列接続して構成されている。

【００５８】平滑コンデンサ５は、上記三相インバータ回路の正負直流電源端間に接続される平滑コンデンサであり、電源ラインを通じて直流電源側にスイッチングノイズが入力されるのを抑止するためのものである。

【００５９】各一対の半導体モジュール１、１の一方は単相インバータ回路のハイサイド側の半導体モジュールをなし、他方は同一相の単相インバータ回路のハイサイド側の半導体モジュールをなす。したがって、３対の半導体モジュール１、１はそれぞれＵ、Ｖ、Ｗ相の単相インバータ回路を構成している。

【００６０】各相の半導体モジュール１、１はその両面を図１に説明したように冷媒チューブ２、２にサンドイッチされており、相が異なる冷媒チューブ２、２の間にそれぞれ扁平円筒形状の平滑コンデンサ５がサンドイッチされている。更に左右最外側の冷媒チューブ２、２には押さえ板６が当接され、両押さえ板６、６の上端部及び下端部にはそれぞれスルーボルト７が積層方向に挿通され、ナット１０により締結されている。

【００６１】ナット１０の締結力は冷媒チューブ２、２による半導体モジュール１の挟圧力が所定値となるように調節されている。すなわち、本実施例によれば、押さえ板６、スルーボルト７及びナット１０からなる挟圧部材は、冷媒チューブ２、２による半導体モジュール１の挟圧力を設定する機能と、三相インバータ回路装置を組み立てし支持する構造部材としての機能とを有している。

【００６２】図３に示すように、各冷媒チューブ２の右端は入り口ヘッダ２３に、左端は出口ヘッダ２４に接合されており、入り口ヘッダ２３の一端は冷媒吸入側の冷媒配管２５に、出口ヘッダ２４の一端は冷媒吸入側の冷媒配管２６を通じてケース４の底部から下方に突出している。２７は冷媒配管２５、２６をケース４の底部に締結、固定するナットである。

【００６３】各冷媒チューブ２には、入り口ヘッダ２３を通じて等流量かつ等温の冷媒が供給され、更に、共通の挟圧部材で挟圧されるため各半導体モジュール１と冷媒チューブ２との間の単位面積当たりの挟圧力は略等しく、挟圧面積も等しいので、半導体モジュール１に対する冷媒チューブ２の挟圧力が略等しくなる。これらの結果、各半導体モジュール１の冷却能力はほぼ等しくすることができる。

【００６４】（変形態様）上記実施例の半導体モジュール１は半導体チップに置換しても同様の作用効果を奏することができる。

【００６５】

【実施例３】図１に示すモジュール１を用いた他の実施例の冷媒冷却型両面冷却半導体装置を図６、図７に示す。

（装置構成）図６は、この半導体装置の蓋を外した平面図を示し、図７はその縦断面図を示す。

【００６６】この実施例の装置は、モジュール１、冷媒チューブ２、平滑コンデンサ５、押さえ板６のセットを実施例２と同一配列とし、このセットを実施例１で説明した板ばね部材９を大型化した大型板ばね部材９０で一挙に挟持させたものである。したがって、大型板ばね部材９０は、ケース４の底部に平行な姿勢で配置される一個の中央板部９０ｂと、この中央板部９０ｂの両端部からそれぞれそれと直角に延設されて互いに対面する一対の平板状の両端部９０ａ、９０ａとからなる。９１は、大型板ばね部材９０の中央板部９０ｂに凹設された条溝部である。

【００６７】本実施例によれば、一層簡単に各部材を組

み立てることができるとともに、各部材にばらつきが小さい挟圧力を与えることができる。

【図面の簡単な説明】

【図１】本発明の両面冷却型半導体モジュール及び冷媒チューブの組み立て厚さ方向断面図である。

【図２】図１に示す半導体モジュールを用いた冷媒間接冷却型半導体装置の平面図である。

【図３】図２に示す冷媒間接冷却型半導体装置の縦断面図である。

【図４】他の実施例の冷媒間接冷却型半導体装置の平面図である。

【図５】図４に示す冷媒間接冷却型半導体装置の縦断面図である。

【図６】他の実施例の冷媒間接冷却型半導体装置の平面図である。

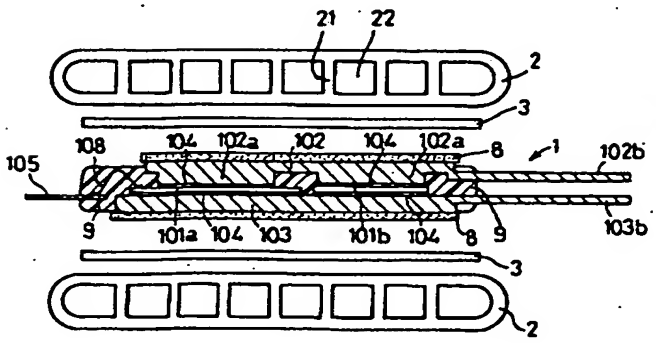
【図７】図６に示す冷媒間接冷却型半導体装置の縦断面図である。

【図８】図６に示す冷媒間接冷却型半導体装置の一部横断面図である。

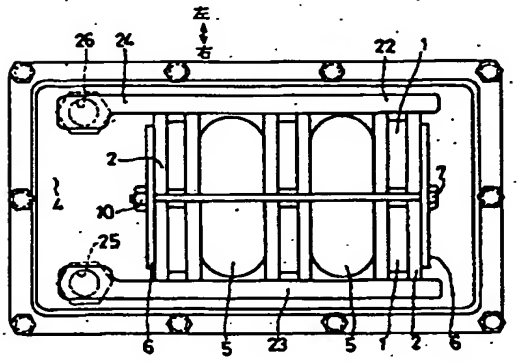
【符号の説明】

１：両面冷却型半導体モジュール
２：冷媒チューブ
６：押さえ板（挟圧部材）
７：スルーボルト（挟圧部材）
９：板ばね部材（挟圧部材）
１０：ナット（挟圧部材）

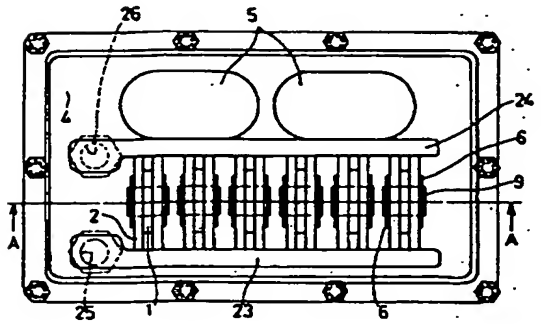
【図１】



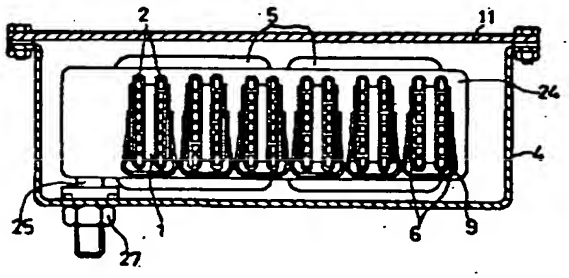
【図４】



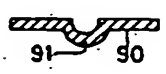
【図２】



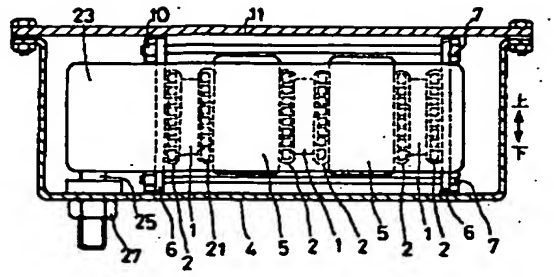
【図３】



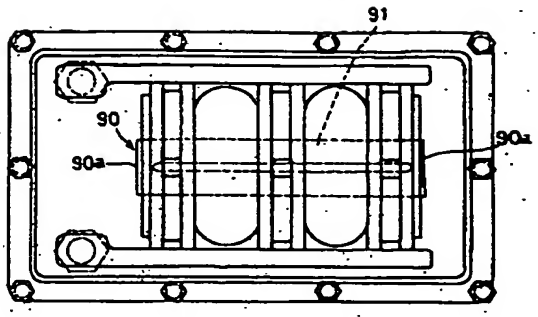
【図８】



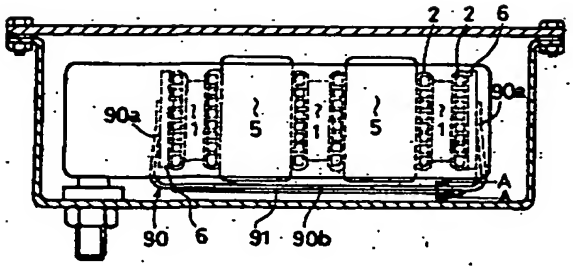
【図５】


23
10
11
7
25
27
6
2
1
21
4
5
2
1
2
5
2
1
2
6
7

【図６】


91
90
90a
90a

【図７】


2
2
6
90a
90a
5
5
A
A
90
6
91
90b

Abstract of JP2001320005

PROBLEM TO BE SOLVED: To provide a double-sided cooling semiconductor device by means of coolant that has simple structure and excellent radiation capability. SOLUTION: While a double-sided cooling semiconduct or module 1 is provide closely to a coolant tube 2 that has a flat contact heat reception surface and allows c ooling fluid to flow inside via an insulating spacer, the double-sided cooling semiconductor module 1 is clam ped by clamping members 6, 7, and 10 in the thickness direction of the double-sided cooling semiconductor module 2 by the coolant tube 2, thus achieving the s emiconductor device that has the simple structure, ex cellent cooling effect, and a small amount of fluctuati on in the cooling effect.